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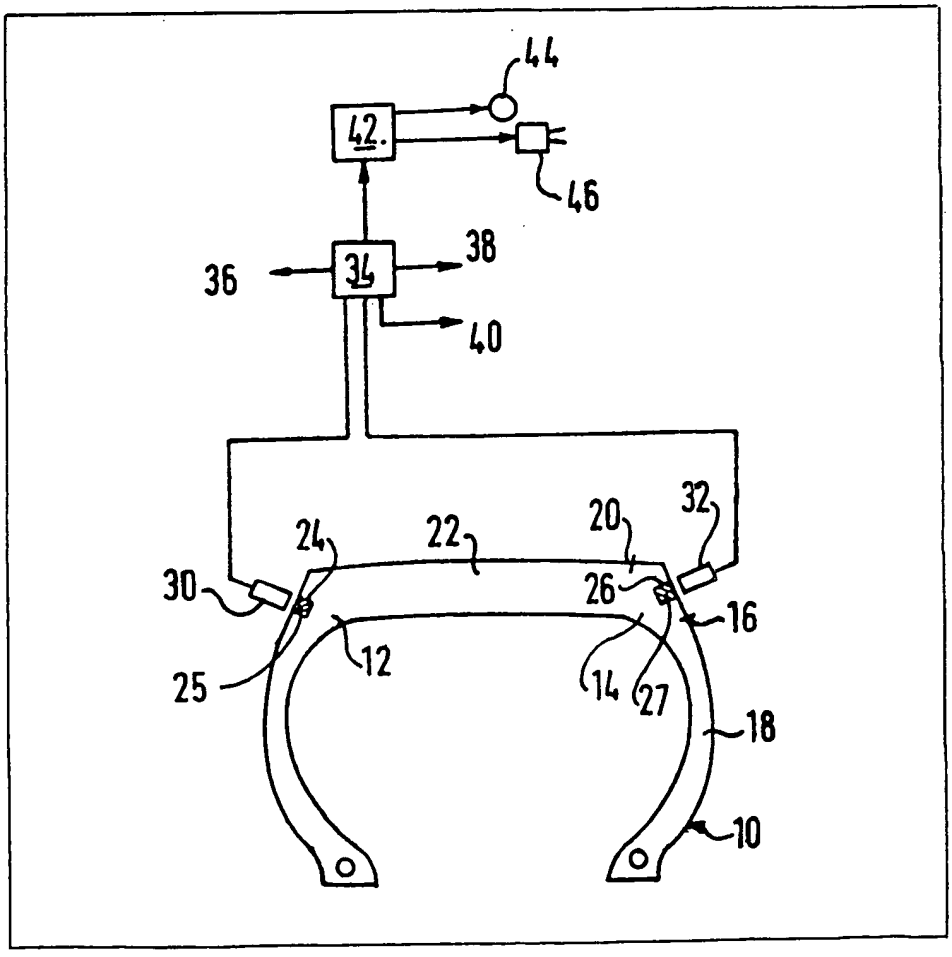
(54) Failure warning systems

(57) A tyre failure warning system comprises a tyre 10 having associated therewith at least one temperature responsive element 25, 27 which is releasable from the tyre 10 at a predetermined temperature and detection and indication means 30, 32, 44, 46 operable in response to the element 25, 27 being released.

The element 25, 27 is preferably positioned in the tyre shoulder region 12, 14 and the predetermined temperature is selected to lie in a range above the maximum safe running temperature of the tyre 10 and a temperature at which the tyre 10 would fail so that advance warning of excessive temperature and potential tyre failure may be obtained.

The element 25, 27 is preferably located in a cavity 24, 26 and formed at least in part from a fusible substance e.g. a metal alloy or a wax, which melts or softens sufficiently at the predetermined temperature that the element 25, 27 is ejected from the cavity 24, 26. The detectors 30, 32 may detect sonic or ultrasonic tones generated by the cavity 24, 26 or when the elements 24, 26 are of metallic/magnetic material, their presence or absence.



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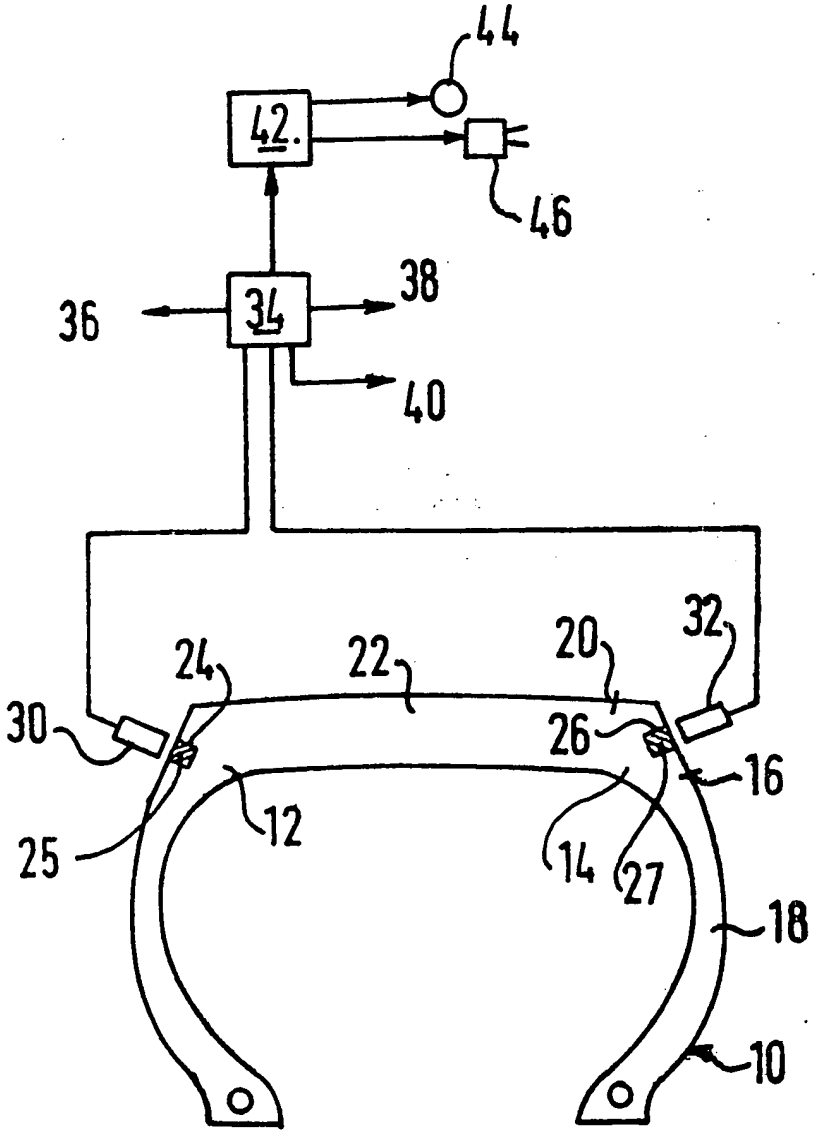

SPECIFICATION

Improvements in or relating to tyre failure warning systems

This invention relates to tyre failure warning systems.

Various forms of warning system have been proposed for indicating to a vehicle driver that a pneumatic tyre of the vehicle has suffered a loss of inflation pressure. However, an indication of tyre failure or a warning of imminent tyre failure can be given by the alternative procedure of detecting an excessive tyre temperature (independently of inflation pressure), and it is with the latter type of warning sytem that the present invention is concerned.

A previously proposed tyre over-temperature detection system involved the use of a thermally sensitive electrical resistor element, which involved technical difficulties in making reliable electrical connection between the tyre-mounted resistor and vehicle-mounted circuitry for responding to temperature-induced variations in electrical resistors. Moreover, the resistor element had to be fitted after manufacture of the tyre, and was therefore possibly outside the quality control of the tyre manufacturer, as well as introducing extra tyre balancing problems.

According to a first aspect of the present invention there is provided a tyre failure warning system comprising a tyre, a temperature responsive element associated with the tyre, said element being releasable from the tyre above a predetermined temperature and detection and indication means operable in response to said element being released to give an indication thereof.

Excessive tyre temperature can be caused by a number of factors including excessive speed, overloading, inadequate inflation and structural damage, e.g. ply separation and may lead to destructive failure of a tyre. The present invention provides a warning system which detects excessive tyre temperature and by appropriate selection of the temperature at which the temperature responsive element is released can possibly give advance warning of imminent tyre failure and so enable remedial action to be taken before failure occurs.

Preferably the predetermined release temperature is selected to lie in the range between the maximum safe temperature of the tyre in normal use, i.e. the maximum temperature at which the tyre may be operated under the conditions the tyre has been designed to meet without significant risk of failure, and the temperature at which the tyre would fail. In order to give maximum advance warning of excessive tyre temperature and therefore potential tyre failure the predet rmined release temperature is preferably selected at the lower end of this range so as to be slightly higher than the maximum safe temperature.

Conveniently temperature responsive element is located in a cavity formed in the tyre, for example during moulding of the tyre. Preferably the cavity is open to the outside of the tyre and the detecting and the indicating means is mounted externally of the tyre.

Heat failure often begins in the shoulder region where, in nearly all cases the highest operating temperature is experienced and therefore in the preferred construction the temperature responsive element is positioned at the shoulder region. By, shoulder region, is meant the part of the tyre extending from the radially outer edge of the sidewall at least as far as the laterally outer regions of the adjacent tread.

In a preferred construction the tyre has a plurality of cavities each containing a respective temperature responsive element distributed around one or both shoulder regions of the tyre whereby the tyre temperature may be monitored at several circumferentially spaced positions thereby reducing the risk of an excessive localised increase in temperature being undetected before tyre failure occurs.

The temperature responsive element preferably includes a substance which is selected to melt or soften sufficiently at the predetermined temperature so as to allow the element to be ejected from the cavity. The element may consist entirely of such a fusible substance. Alternatively the element may comprise a composite of such a fusible substance together with a non-fusible inset consisting of one or more, preferably solid, objects. Suitable fusible substances include metal alloys or waxes the compositions of which may be chosen to give the required melting /softening temperature while the insert, where provided, may be of non-metallic material e.g. plastics but more preferably is of metallic material e.g. aluminium or copper and in certain applications may advantageously also be of magnetic material e.g. iron.

The element may be formed in situ by casting an appropriate amount of the fusible substance with or without an insert into the cavity in the tyre. Alternatively the element may comprise a pre-formed plug which may be inserted into the cavity when required. Provision of pre-formed plugs enables the user to replace an ejected plug following operation of the warning system.

The cavity may be constructed to positively retain the element therein during normal use. Thus where the element is formed in situ or comprises a pre-formed plug the cavity may be of frusto-conical profile wider at the base than the mouth or the cavity may have an internal locating formation such as an annular groove in which a complementary locating formation on the element is received.

Alternatively where the element comprises a pre-formed plug the latter may be formed slightly oversize so as to be an interference fit

in the cavity.

The detection and indication means may comprise means to detect sonic or ultrasonic tones or noise generated by an empty cavity or cavities as an over-heated tyre rotates in the surrounding atmosphere, coupled to a suitable audibl and/or visible warning device or d vices preferably located adjacent to the vehicle's driving position, and the cavities are preferably shaped and dimensioned to enhance such tone or noise generation.

Alternatively where the temperature responsive element is formed by or includes sufficient metallic or magnetic material the detection and indication means may comprise any suitable metal/magnetic detection means coupled to a suitable indication device whereby the detection of metallic/magnetic material in the cavities will indicate that the tyre remains below the predetermined temperature, and conversely, failure to detect the presence of metallic/magnetic material in the cavities will indicate that the tyre has exceeded the predetrmined temperature or that the warning system has failed. The last-mentioned mode of operation is therefore inherently "fail-safe" and represents another advantageous facet of this form of the invention.

According to a second aspect of the invention there is provided a tyre for use in the warning system of the first aspect of the invention, the tyre having at least one temperture responsive element associated therewith, said element being releasable from the tyre above a predetermined temperature.

Preferably the element is located in a cavity in the tyre, preferably in the shoulder region.

Preferably the tyre has a plurality of cavities each containing a temperature responsive element distributed around one or both shoulder regions of the tyre. The tyre can be manufactured and vended with the element located in the cavity. Alternatively the tyre can be provided as a kit of parts comprising the tyre with one or more unfilled cavities, together with preformed elements for insertion into the cavity or cavities, or with a mass of fusible substance in a form suitable for casting into the cavity or cavities with or without additional objects as above-described.

The invention will now be described in more detail, by way of example only, with reference to the accompanying drawing, the single Fig. of which is a schematic representation of a tyre failure warning system according to the present invention.

The tyre failure warning system shown in the accompanying drawing includes a tyre 10 shown diagrammatically in transverse cross-section, the wheel on which the tyre 10 is mounted being omitted for clarity. The tyre 10 may be any form of radial ply or cross-ply or belted-bias pneumatic tyre, or a solid tyre, the precise structure of the tyre 10 being immaterial for the purpose of this description.

The tyr 10 has two shoulder regions 12 and 14, ach extending (as indicated for the shoulder 14) from the radially outer edge 16 of a sidewall 18 as far as a point 20 in the laterally outer regions of the adjacent tread 22. Each of the shoulder regions 12 and 14 has a plurality of cavities circumferentially distributed around the tyr 10, the Fig. showing only one such cavity 24 in the shoulder region 12, and another such cavity 26 in the shoulder region 14. The cavities 24 and 26 are shown only diagrammatically, and their optimum shapes, sizes and locations may be determined by non-inventive trial and experiment having regard to the general principles of the invention as described in this specification.

Each of the cavities, including the illustrated cavities 24 and 26, is filled by a temperature responsive element 25 and 27 respectively composed of a normally solid fusible substance having a melting or softening temperature substantially equal to a predetermined temperature which is excessive having regard to the structure and normal working conditions of the tyre 10 and preferably only marginally above the normal maximum safe temperature for the tyre 10 so that when the tyre is heated to the predetermined temperature the substance melts or softens sufficiently either to flow out of the cavities under gravitational force or so as to be thrown out of the cavities by centrifugal force induced by rotation of the tyre 10. The substance may, for example be an alloy comprising three or more of the elements bismuth, lead, cadmium and tin, or a non-metallic thermoplastic material, e.g. a paraffinic wax having a composition giving the required melting or softening temperature. Alternatively, each of the cavities may be filled by an element comprising one or more suitable objects, e.g. a shaped piece or pellets of aluminium or copper, or a magnet, secured in the cavity by a quantity of fusible substance of the kind described above.

The tyre failure warning system further includes two detectors 30 and 32, which are suitably fixed on the body of the chassis (not shown) of a vehicle which is supported by the tyre 10, and such as to be in suitable proximity to and alignment with the cavities. The detector 30 is fixed adjacent to the tyre shoulder region 12 and the detector 32 is fixed adjacent to the tyre shoulder region 14. The detectors 30 and 32 can be any suitable devices capable of detecting the presence in or th absence from the cavities 24 and 25 of the temperature responsive elements 25 and 27. If the elements 25, 27 ar formed by or include sufficient metallic material the detectors 30 and 32 may be metal detectors responding either to the presence in or absence from the cavities of the metallic material, or which positively respond in either case. Alternatively, whether the elements 25, 27 are

metallic or non-metallic, and the detectors 30 and 32 have to respond only to empty cavities, the detectors 30 and 32 may be audio-frequency transducers (e.g. microphones) operated by sonic or ultrasonic tones or noise generated by motion of empty cavities due to tyre rotation in the surrounding atmosphere, and in this case the cavities are preferably shaped and dimensioned to be suitably powerful sonic-power generators, e.g. by being formed as sonically resonant cavities. The sound may be generated by the normal rotation of the tyre, and/or the passage of gas (e.g. air), from suitably disposed nozzles mounted on the vehicle so as to augment the flow of gas across the cavities.

The detectors 30 and 32 are coupled to a central detection signal processing and control unit 34 which also receives equivalent signals (designated 36, 38 and 40) from other detectors (not shown) associated with other tyres (not shown) of the vehicle, these other tyres being formed similarly or identically to the tyre 10 in respect of the cavities containing temperature responsive elements.

The detection unit 34 is coupled to an indication control and power supply unit 42 such as to operate a visual warning device 44 (e.g. a flashing lamp) and/or an audible warning device 46 (e.g. a buzzer, horn or siren) in accordance with temperature conditions detected in one or more of the tyres, and in particular so as to give distinct and preferably imperative warning of a detected excess temperature in any tyre included in the warning system. The warning devices 44 and 46 are preferably mounted adjacent the vehicle's driving position so as to be readily seen or heard by the driver and may give an indication of the precise tyre in which an excess temperature has been detected.

Modifications and variations of the above-described and illustrated embodiment are possible within the scope of the invention. For example, different arrangements of cavities and detectors are possible, e.g. cavities and a detector may be associated with only one tyre shoulder, and in the limiting case, there may be only one insert-filled cavity in each shoulder region, or in only one shoulder region. For increased reliability, more than one detector may be associated with each shoulder, and duplicated detectors may be of the same or different types. Alternate cavities may be filled with temperature responsive elements which melt or soften at different temperatures, whereby for example it may be possible to give warning of a slightly excessive temperature and also of a higher and more dangerous excessive temperature.

The detection and indication circuitry has been only diagrammatically illustrated, and can take any suitable form which adequately serves the requisite functions. Circuit test means (not shown) may be incorporated for checking correctness of operation. The circuitry is preferably constructed and operated in any well-known fail-safe manner.

CLAIMS

1. A tyre failure warning system comprising a tyre, a temperature responsive element associated with the tyre, said element being releasable from the tyre above a predetermined temperature and detection and indication means operable in response to said element being released to give an indication thereof.

2. A system according to claim 1 wherein said pre-determined temperature is selected to lie in the range between the maximum safe temperature of the tyre in normal use and the temperature at which the tyre would fail.

3. A system according to claim 2 wherein said predetermined temperature is selected to lie at the lower end of said range.

4. A system according to any one of the preceding claims wherein the temperature responsive element includes a fusible substance which melts or softens at the predetermined temperature.

5. A system according to claim 4 wherein said fusible substance is metallic.

6. A system according to claim 5 wherein said fusible substance is an alloy comprising a mixture of three or more of bismuth, lead, cadmium and tin.

7. A system according to claim 4 wherein said fusible substance is non-metallic.

8. A system according to claim 7 wherein said fusible substance is a wax.

9. A system according to any one of claims 4 to 8 wherein said element consists entirely of said fusible substance.

10. A system according to any one of claims 4 to 8 wherein said element comprises a composite of said fusible substance together with a non-fusible insert.

11. A system according to claim 10 wherein said insert is metallic.

12. A system according to claim 10 wherein said insert is non-metallic.

13. A system according to claim 10 wherein said insert is magnetic.

14. A system according to any one of the preceding claims wherein said element is located in a cavity in the tyre.

15. A system according to claim 14 wherein said cavity is open to the outside of the tyre.

16. A system according to claims 14 or 15 wherein said element comprises a preformed plug.

17. A system according to claims 14 or 15 wherein said element is formed in situ in the cavity.

18. A system according to any one of claims 14 to 17 wherein the cavity is constructed to positively retain the element therein up to said predetermined temperature.

19. A system according to claim 16 wherein said plug is formed slightly oversize so as to be an interference fit in the cavity.

20. A system according to any one of claims 14 to 19 wherein the detection and indication means is operable to detect sonic or ultrasonic tones or noise generated by the cavity following release of the associated element and actuate a warning device.

21. A system according to any one of claims 14 to 19 wherein the detection and indication means is operable to detect the presence of the element in the cavity and actuate a warning device following release of the element.

22. A system according to claim 21 wherein the element includes a metallic material and the detection means is a metal detector.

23. A system according to claim 21 wherein the element includes a magnetic material and the detection means detects the presence of said material.

24. A system according to claim 20 or 21 wherein the warning device is operable to produce a visual and/or audible warning signal.

25. A system according to any one of claims 14 to 24 wherein the cavity is positioned in a shoulder region of the tyre.

26. A system according to claim 25 wherein the tyre has a plurality of cavities each containing a respective element in said shoulder region of the tyre and the detection and indication means is operable in response to the release of any one of the elements to give an indication thereof.

27. A system according to claim 26 wherein said cavities are uniformly spaced in a circumferential direction.

28. A system according to claim 26 or claim 27 wherein said elements are releasable at the same predetermined pressure.

29. A system according to claim 26 or claim 27 wherein said elements are releasable at different predetermined temperatures.

30. A system according to any one of claims 25 to 29 wherein the tyre has at least one cavity containing a respective element position in the other shoulder region of the tyre and respective detection and indication means is provided for each shoulder region of the tyre.

31. A tyre failure warning system substantially as hereinbefore described with reference to the accompanying drawing.

32. A vehicle provided with a tyre failure warning system according to any one of the preceding claims.

33. A vehicle according to claim 32 wherein the system is operable to give an indication of a particular tyre in which an excessive temperature has been detected.

34. A tyre for use in the tyre failure warning system according to any one of claims 1 to 31, the tyre having at least one temperature responsive element associated therewith, said element being releasable from the tyre above a predetermined temperature.

35. A tyre for use in the tyre failure warning system according to any one of claims 1 to 31 the tyre having at least one cavity therein adapted to receive a temperature responsive element which in use of the tyre is released from the cavity at a predetermined temperature.

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